Volume 43 MAY, 1957 Number 5

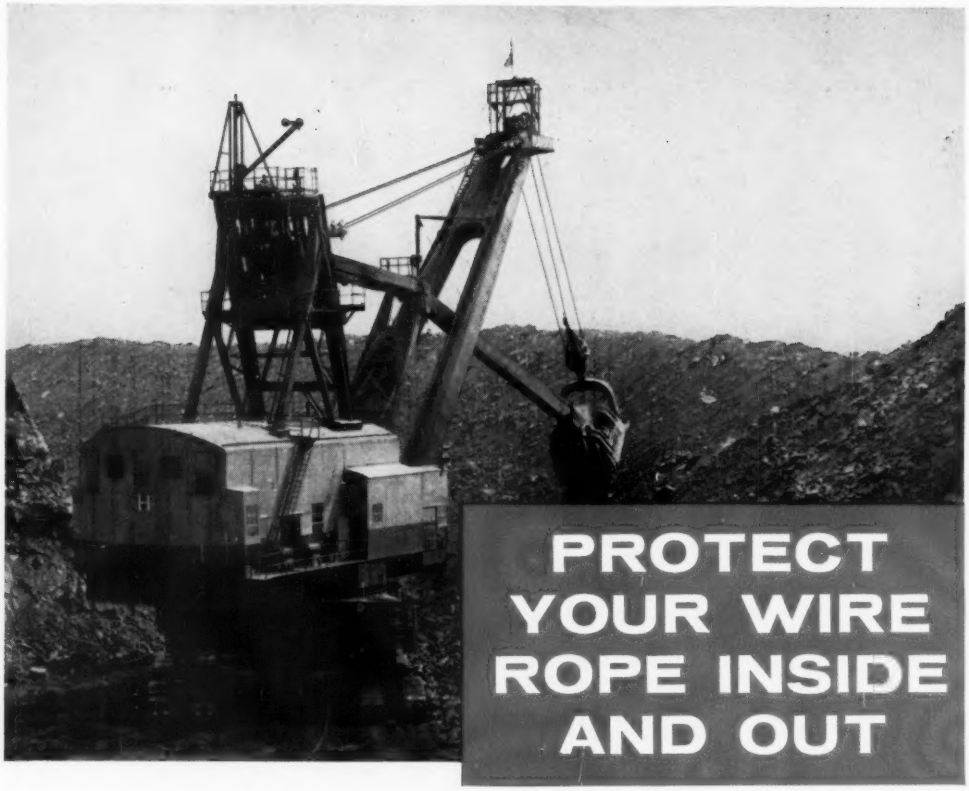
# Lubrication

## A Technical Publication Devoted to the Selection and Use of Lubricants

*This Issue*

NEW DEVELOPMENTS
IN SURFACE
MINING EQUIPMENT

PUBLISHED BY
THE TEXAS COMPANY
TEXACO PETROLEUM PRODUCTS



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# LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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# New Developments in Surface Mining Equipment

WHERE large bodies of metallic ore, coal or other valuable minerals lie very close to the earth's surface they can often be mined by first digging away all the earth and rock covering the deposit and then digging out the deposit itself. Since the entire operation is carried on in the open, it is referred to as open pit or surface mining, as contrasted to underground mining in which shafts and tunnels are driven selectively into the pay material (material of value). In its broadest sense, surface mining also includes the products of quarries, such as crushed rock and limestone. This is understandable, since the process of removing the pay material is essentially the same in any open pit operation, regardless of the material involved.

The volume of material mined by open pit methods is truly astronomical. If the products of quarries are included, combined output in 1956 totaled slightly over 1 billion tons. Even this represents only a fraction of the material that must be handled by the equipment used when it is considered that the earth and rock (called overburden) covering the pay material must also be removed before the pay material can be mined. Some idea of just how great a factor this overburden represents can be obtained by considering the ratio of overburden to pay material in two cases. (1) A representative iron mine is removing roughly 3 cubic yards of overburden per ton of ore. (2) A coal mine is stripping off a 40 foot layer of overburden to uncover a 4 foot seam of coal. These are by no means extreme ratios of overburden to pay material for the two industries mentioned. The ratio varies both with the material mined and from location to location.

It is obvious that the success of surface mining operations is closely keyed to the efficiency with which these staggering quantities of material can be handled. Modern open pit operations were made possible only through the development and continuous improvement of power equipment. As equipment performance and economy increased, it became feasible to mine deposits that lay deeper in the earth by open pit methods instead of resorting to underground mining which is more dangerous and complicated, and which must leave some of the pay material to support the earth above it. Technical improvements have also made possible the processing of low grade ores in competition with richer deposits.

## OVERALL TRENDS IN EQUIPMENT USED

Developments over the past few years have been characterized primarily by the INCREASED

*Courtesy of Caterpillar Tractor Co.*

**Figure 1 — Tractor-Drawn Scraper and Bulldozer Removing Top Soil in Starting a New Mine.**

CAPACITY of existing types of equipment. In addition, some entirely new techniques and equipment have been introduced. Accompanying the general increase in capacity, equipment manufacturers have also improved the performance, reliability and economy of their products. The striking advances in equipment are in large part due to:

(1) The increase in engine horsepower, efficiency, and dependability, particularly in the diesel field.

(2) Wider use of electric motors as a primary power source on larger equipment with resultant compactness, increase in maximum power and greater flexibility of control.

(3) Introduction of torque converters and semi-automatic transmissions in practically all types of excavating equipment with resultant torque increase at low speeds, reduced shock loading in the power train, reduced operator fatigue and ease of synchronizing dual-engine power.

(4) Liberal use of hydraulic and pneumatic power thereby permitting more sensitive control, eliminating cumbersome power-take-offs and linkages, affording flexibility in design and reducing manual effort.

(5) Development of rubber tires with increased load capacity and improved wear resistance. The use of nylon cord and tubeless designs has been of major importance.

(6) The utilization of tougher alloys and welded construction permitting weight savings by using structural members of reduced section.

In addition to these general factors, many design changes have been made by individual equipment manufacturers which have improved the performance of their equipment. For obvious reasons it would be impossible in a survey article of this length either to cover specific design aspects in detail or to include all the equipment modifications that are incorporated in order to handle a particular type of material.

In the following sections, only the predominant features of the major types of equipment used are discussed.

## DESCRIPTION OF OPEN PIT OPERATIONS AND THE EQUIPMENT USED

The equipment used in surface mining can be grouped into three broad categories representing basic functions in the mining process, namely: (1) Excavating, (2) Transporting, (3) Processing.

These three functions sum up quite a few individual steps in open pit mining so that a brief description of the general sequence of open pit operations would be helpful at this point in understanding how and why certain equipment is used.

As pointed out earlier, it is necessary to dig away the overburden before the pay material can be moved. Bulldozers first clear away trees and top soil. Then the overburden is dug away either with shovels or draglines, or if sufficiently thin and soft, by using scrapers. In most cases, the hardness of the overburden requires drilling and blasting before the shovels or draglines can handle it.

*Courtesy of Marion Power Shovel Co.*

**Figure 2 — World's Largest Shovel Stripping Overburden in Coal Mine With 90 Ton Bites. Note How Side-Casting Method of Removing Overburden Resembles Plowing on a Giant Scale.**

*Courtesy of The Thew Shovel Company*

**Figure 3 — Small Shovel Digging and Loading Coal. Thickness of Coal Vein Can Be Seen Clearly. Dragline in Background Has Previously Stripped Overburden.**

The next problem is the disposal of the overburden. In deep pits such as iron mines, it must be hauled to a dump either by truck, railroad car, or a combination of haulage equipment. Where the overburden is not too great and the pay material is in a relatively thin layer such as coal, the shovel or dragline travels along the face of the overburden, picks up what has been blasted loose, swings 180 degrees and casts it on an area where the pay material has already been dug out. The overall result as the shovel moves along the face of the overburden resembles plowing on a giant scale.

Once the overburden has been removed from a particular area, the pay material is dug out. This can be done directly by the loading shovel if the material is sufficiently soft. If not, blasting must again be employed to break up the formation before it can be handled by the shovel or dragline. As in the case of the overburden, the material is removed from the mine either by a truck or railroad car and is then transported to a central processing plant.

In unusually deep pits, both overburden and pay material are removed by using a combination of haulage equipment. Either conveyors, cable lifts, or a form of inclined railway is used to bring the material from the bottom to the top of the pit because they can handle steeper grades. Separate groups of either railroad cars or trucks are still used at the bottom and top of the pit. In general, multiple handling increases costs and is, therefore, avoided wherever possible.

Processing plants reduce the material to the desired size or sizes, wash it in some cases, and reduce ores to the desired concentration before shipment. Screens, crushers, ball and rod mills, magnetic and centrifugal separators, scrubbers, settling tanks, and dryers are among the variety of equipment that is used.

In addition to the basic operations some auxiliary functions are necessary which require a considerable amount of time and equipment. These include: (1) Laying out and maintaining access to roads and/or railroad tracks to the pit. (2) Providing drainage in the working areas of the pit. (3) Building reservoirs and settling ponds to supply water to the processing plant and to handle the waste residue from the plant. (4) Leveling of spoil dumps where state law requires this to be done.

## DESIGN FEATURES OF BASIC EQUIPMENT USED

The salient characteristics of most of the basic pieces of equipment currently being used in open pit mining are discussed below. Where the equipment is likely to be very familiar to most readers because of its use in other industries, less emphasis has been placed on describing the units. This is true of railroad equipment and some of the more common pieces of earth moving equipment.

It should also be mentioned at this point that the lubrication requirements of each machine are not covered individually but will be discussed in a separate section on lubrication. As will be seen, this will save undue repetition because the various pieces of equipment are made up of essentially the same basic components from a lubrication standpoint. By this is meant such items as engines, bearings, transmissions, open gears, etc.

### Excavating Equipment

*Bulldozers, Scrapers, Loaders and Graders*

These machines are standard units such as those purchased by construction contractors and are

grouped because of their similarity. Graders are included because they are used to maintain the pit roads. In mining operations the larger sizes offered by the equipment manufacturers are generally used since power and capacity are more important than versatility.

Due to the relatively steep grades and heavy materials moved, tractors and dozers of the crawler type are more prevalent. The crawler tracks also provide lower unit ground pressure hence, better support on soft ground.

Diesel engine power is used almost exclusively, having single engines developing as high as 400 horsepower. Twin-engine designs of tractors and loaders are available with as high as 518 horsepower combined. The horsepower of many units has been boosted by the use of supercharging, that is, crowding more air into the engine cylinders. At present, turbine-driven superchargers operated by the flow of exhaust gases are becoming popular.

Torque convertors are in wide use to transmit power from the engine to the drive system. Their advantages have already been pointed out in the discussion of overall design trends.

Hydraulic systems for actuating the various movable parts such as blades, buckets, and scraper bowls have come into widespread usage, giving better control and smoother operation. Refinements in cable and electrical controls on some units have also accomplished the same results.

*Blast Hole Drills*

In order to keep up with the greatly increased handling capacity of modern power shovels and trucks, mine and quarry men are continuously seeking ways to drill blast holes faster and more economically. Great strides have been made in drilling equipment designed to achieve these goals.

Blast holes of larger diameter are being bored, thereby either permitting the use of fewer holes to break up a given quantity of material or else giving better fragmentation with the same number of holes. The use of blast holes varying from 6″ to 12″ in diameter is now common. To handle the larger drilling equipment required, it has become necessary to mount it on self-propelled carriers usually of crawler-tread design. These carriers permit movement from hole to hole with very little delay in set-up time. The self-propelled carriers are generally integral units containing an air compressor as well as the necessary power for traveling and operating the drill. Once the rig is in place over a hole site, it is levelled by hydraulic jacks built into the unit. The drills on these units are mounted on towers that are as much as 50 feet high, permitting a hole to be bored continuously without having to stop and insert additional drill sections.

A choice of either electric or diesel primary power is offered. However, most of the larger mines use electrically powered equipment. The way in which the primary power source is used to actuate the individual components varies with the equipment manufacturer. All manufacturers use hydraulic and pneumatic systems to varying degrees to perform some of the following functions: Actuate and load the drill, raise and lower the tower, propel the unit, and drive the dust collector. In the case of hydraulic power, an electric motor drives oil pumps which in turn operate hydraulic motors and cylinders. The pneumatic systems use the output of the air compressor to operate air motors or pistons.

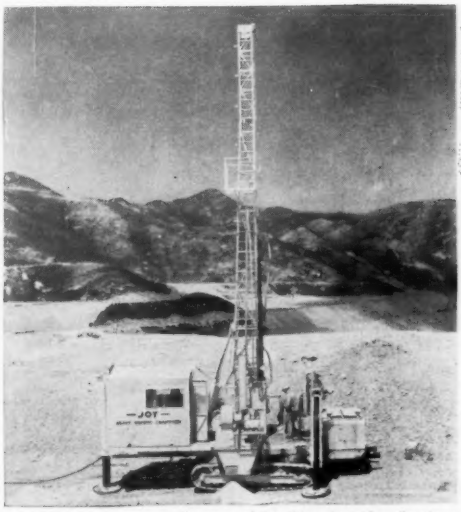
Many changes have also taken place in the drills themselves. The basic percussion type drill, which is essentially a magnified jack-hammer, has undergone improvements in the metallurgy of the drill steel. Also, the use of detachable bits made of special alloys or of tungsten carbide has reduced drill wear. One manufacturer makes a percussion drill which actually goes down a 6½″ hole. This eliminates the power loss caused by transmitting hammer blows through long rods, couplings, etc.

Rotary drills have come into widespread use. They are similar in principle to those which have been used for many years in oil field work. The bits are of the tri-cone roller type and are available in various tooth designs for use in rock of different hardness. The three cones are free to rotate under the pressure of the bit against the bottom of the hole. Compressed air is forced continuously down through the drill pipe to remove the cuttings from the face of the bit. These cuttings are forced to the surface around the outside of the drill pipe to the collar of the hole where they are picked up by a dust collector. The air blast also serves to cool the rotary bit.

Another and relatively new process which has been found to give very high drilling rates in hard, spallable ore and/or rock formations is jet piercing. In this process, a high velocity, high temperature flame, produced by burning a light distillate fuel such as kerosene with oxygen, is used to produce spalling of the rock or ore by imposing thermal stresses. The oxygen and fuel are mixed in a burner head at the tip of a blowpipe that goes down the hole the same as a conventional drill does. The burner and blowpipe rotate continuously during this process. In addition to the oxygen and fuel oil, water is directed into the combustion zone during burning for two purposes: (1) to aid in spalling, and (2) to prevent the 4500°F. burning temperature from melting the burner. The steam formed as the water comes into contact with the products of combustion mixes with them, and the entire mixture rises at supersonic speeds around the blowpipe to the surface. This jet carries along the dis-

*Courtesy of Bucyrus-Erie Company*

Figure 4 — Rotary Blast Hole Drill. This Electrically-Powered Unit Can Drill Holes up to 12¼″ in Diameter. A Hydraulic Motor and Cable Are Used to Pull Down and Feed the Drill.



*Courtesy of Joy Manufacturing Company*

Figure 5 — Blast Hole Drill in Use in Copper Mine. This Unit Drills up to 7⅞″ Holes and Has a Twin-Cylinder Direct Hydraulic Drill Feed.

*Courtesy of Joy Manufacturing Company*

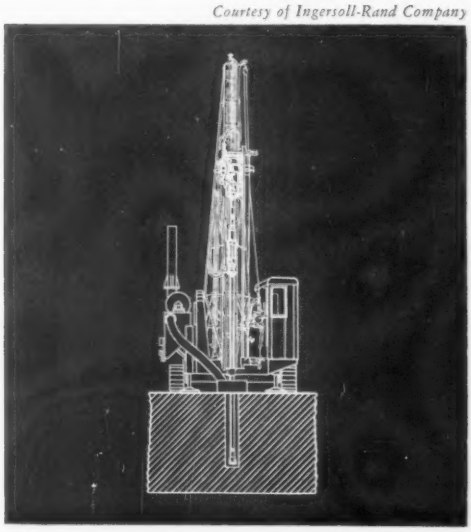
Figure 6 — Tri-Cone Roller Type Rotary Drill Bit.

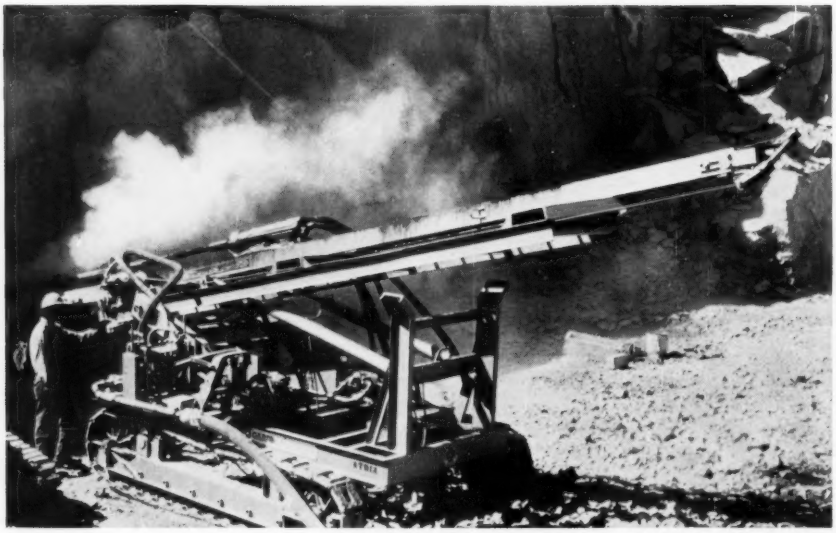
Figure 7 — Jet Piercing Machine. Kerosene, Oxygen and Water Combine to Drive a Hole in the Ground by Spalling Action. Escaping Steam in Horizontal Stack Sounds Like a "Banshee's Wail."

*Courtesy of Bucyrus-Erie Company*

Figure 8 — Sectional View of Rotary Drill in Action. This Unit Uses an Air Motor to Rotate the Drill.

*Courtesy of Ingersoll-Rand Company*





*Courtesy of Gardner-Denver Company*

**Figure 9 — 5½" Crawler-Mounted Drill. Remote Compressor Powers Drill and Crawler Motors.**

integrated particles of rock about half of which are less than 1/16 inch in diameter. The rest are in the form of paper-thin shavings up to an inch long.

The rate at which the blowpipe is lowered into the hole formed is controlled automatically. In taconite mining a jet piercing machine can put down a 6½ inch diameter hole at an average rate of 15-20 feet per hour.

*Compressors*

Compressors are used primarily to furnish air to the blast hole drilling rigs. As pointed out above, the compressors generally are mounted directly on the drilling rig. In quarry work and some mining operations, however, portable compressors are used to power wagon drills or crawler mounted drills.

In the portable field, and to a lesser extent on the larger self-propelled drilling rigs, oil-flooded rotary compressors are coming into wide scale use. These operate on the principle of a sliding vane air motor. In this type of compressor, copious quantities of oil are injected into the compression chamber where it acts as a sealing medium, as a coolant, and as a lubricant. The cooling of the air by the oil during compression increases the thermal efficiency of the unit. Baffle type filters are used to remove oil from the compressed air. The extracted oil is then cooled either by passing through a water jacketed heat exchanger or through an air cooled radiator.

The rotary compressors are from 30 to 35% lighter and more compact than comparable two-stage reciprocating compressors. They have the advantage of fewer moving parts, ease of disassembly and elimination of pulsations in the air flow.

In mining work, both rotary and reciprocating compressors are either electric or diesel powered.

*Coal Augers*

A relatively new development in the strip mining of coal is the use of coal recovery drills to extract coal from the face of the pit when the overburden becomes so thick as to make further stripping uneconomical. These drills range from 16 to 52 inches in diameter.

In this method, the coal drill is brought into position alongside the exposed seam and the drill bores horizontally into the coal seam. The coal is worked back toward the machine by the drill flutes where it is picked up by a conveyor and loaded on the truck or other carrier. By adding additional sections of drill as the hole progresses into the face of the pit, penetrations as great as 200 feet can be achieved. The process is repeated along the entire pit face leaving thin sections between adjacent holes to support the overburden.

The units are diesel powered and the drills are driven through reduction gearing. A hydraulic pump supplies oil under pressure to operate leveling jacks, a lifting crane, auger guides, pistons which move the drill carriage into the coal face to supply pressure to the drill, and pistons which push the entire unit along tracks parallel to the face between successive holes. The loading conveyor usually is integrated with the unit.

*Power Shovels and Draglines*

The initial growth of large scale open pit mining is perhaps most closely tied to development of

the power shovel than to any other single piece of equipment.

In mining work, the preponderance of the larger shovels and draglines are entirely electrically powered because of compactness, economy of operation, ease of maintenance and simplicity of control. Some of the smaller operations use gasoline, diesel-mechanical or diesel-electric units. Where engines are used, torque converters are being employed to increase smoothness of operation and operating efficiency. Steam powered shovels which pioneered the power shovel are almost nonexistent today.

The general configuration of the basic shovel and dragline components has not changed drastically over the years, still consisting of a travelling base on top of which is seated a revolving deck containing the operating mechanism and on which the dragline boom or dipper stick is mounted. The draglines generally move from location-to-location by means of a walking shoe arrangement although crawler mounts are also used. Shovels are mounted on crawler track mechanisms. Draglines, as the name implies, drag a free-falling bucket toward the machine by means of a cable.

The outstanding developments have been in size, power and methods of control. The optimum size of shovels and draglines varies with the material being mined and the layout of the pit. In iron mining, shovels of 5 to 8 cubic yard capacity are common sizes, although a 10 yard shovel which is the largest on two tracks has recently been made available. On the other hand, in strip mining of coal where overburden is sidecast, progressively larger shovels are being employed. At this writing, the largest shovel in use has a 60 cubic yard bucket. This giant cost $2.6 million dollars and stands as high as a 16 story building. It has 16 electric motors totaling 9,000 horsepower. The more than 500 bearings on this shovel are lubricated by an automatic lubrication system.

In all-electric machines, the most common control system is called Ward-Leonard. Line power is brought into the revolving deck through collector rings where a large alternating-current motor drives three or more generators each of which supplies a direct current motor powering a main motion. Other electrical and electronic systems are being developed to simplify handling the large currents and voltages safely. However, they are too involved to describe briefly.

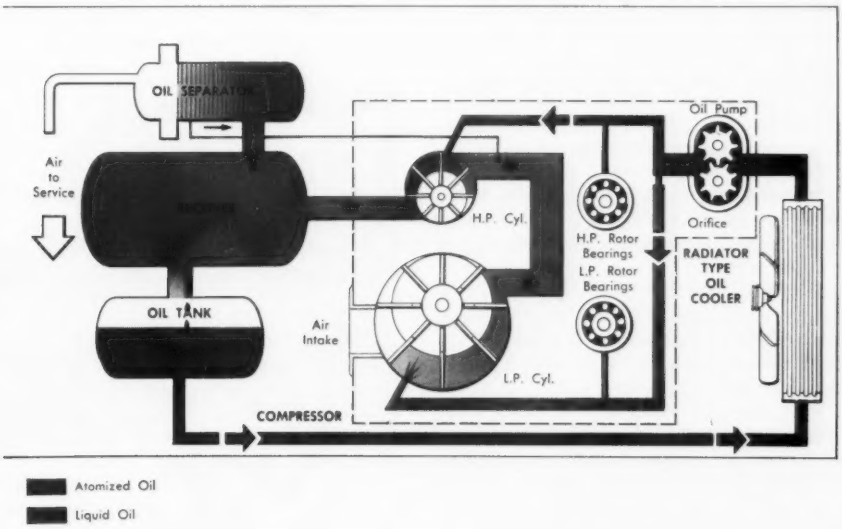
Control of the different motions varies with the type of drive. In engine-powered units, both friction brakes and magnetic clutching systems are in use. The latter has the advantage of absorbing shock loads. Friction brakes are controlled by either hydraulic or pneumatic systems. In all-electric units regenerative action of the motors is a common system used in braking.

Centralized grease lubrication systems and the use of copper lines and grouped fittings leading to hard-to-reach points are being used more widely.

## Transportation Equipment

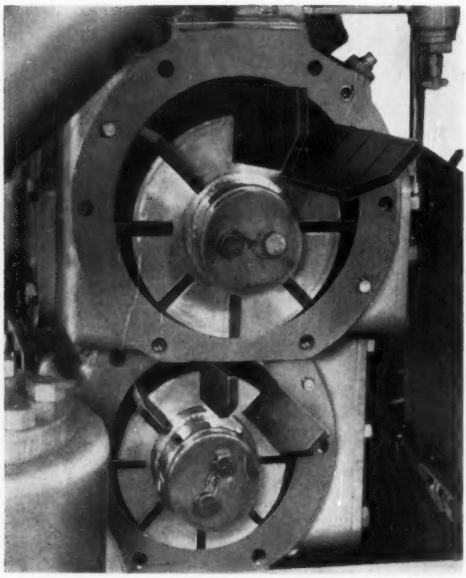
*Railroad Equipment*

Until the development of dependable off-highway trucks, rail was the predominant form of




*Courtesy of Chicago-Pneumatic Tool Company*

**Figure 10 – Schematic Diagram Showing Oil and Air Flow in a Two-Stage Rotary Compressor.**



*Courtesy of Gardner-Denver Company*

**Figure 11 — End Plates Removed From Two-Stage Rotary Compressor Showing Blades and Rotors.**

transportation in large mines. Now they are used only for long hauls or in the largest mines.

Early equipment ran on narrow gage track. Today, standard gage cars and diesel-electric locomotives are used in most cases. This equipment has not changed radically over the last few years and should be fairly familiar to most readers.

*Trucks*

Many types of trucks are used in open pit operations. Although small-scale operators may use standard heavy-duty highway equipment, the major hauling is done with giant off-highway units. These can negotiate a 12% grade with full load, as compared to one of 3% for railroad equipment, thereby reducing by as much as 75% the horizontal distance that must be travelled in hauling out of a given depth mine.

Designs vary considerably. Both rear dump and tractor-trailer types are used. The tractor-trailers can unload either by tilting sideways or else through an opening bottom whose action resembles that of a clamshell bucket. Capacities have increased greatly. Rear dumps carrying up to 50 tons and tractor-trailer haulers of up to 51 ton capacity are available. These are maximum sizes, and units from around 22 to 34 tons are currently more prevalent.

Horsepower has risen tremendously. Twin-engines are used in some cases to achieve this power increase. Rear dumps run as high as 600 horsepower and tractor trailers up to 400. Again these are maximums. Diesel engines are used almost exclusively in off-highway equipment, although some LPG (liquefied petroleum gas) engines are available. Turbo-superchargers are being used to obtain the horsepower ratings mentioned.

Torque converters, power brakes, and power steering are standard equipment on most units.

Tandem axle designs are used in conjunction with twin power in some units with each axle being powered by one engine. Four-wheel drives are widely used in tractor trailers.

Hydraulic retarders have improved safety and reduced brake wear on downhill grades.

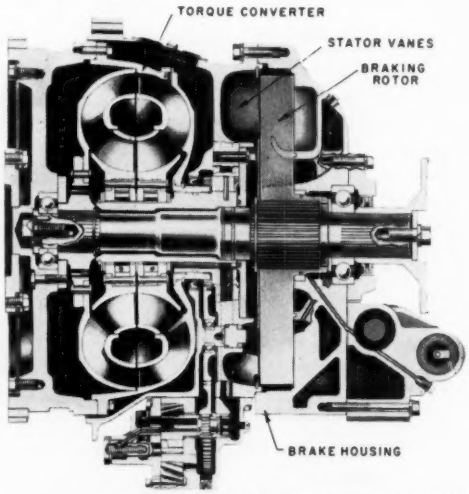
Improved tires have reduced down time for tire repair and increased maximum load per axle thereby permitting larger designs without adding more axles.

To prevent frozen iron ore from adhering to the dump body in northern winter operation, provision has been made to channel the engine exhaust gases through hollow passages on the reinforcing members of the dump box. A slide fit joint automatically disconnects the system when the box elevates for dumping.

Automatic lubricators have been employed on large tractor-trailer coal haulers. In one 60 cubic yard unit, 64 wear points are being lubricated automatically.

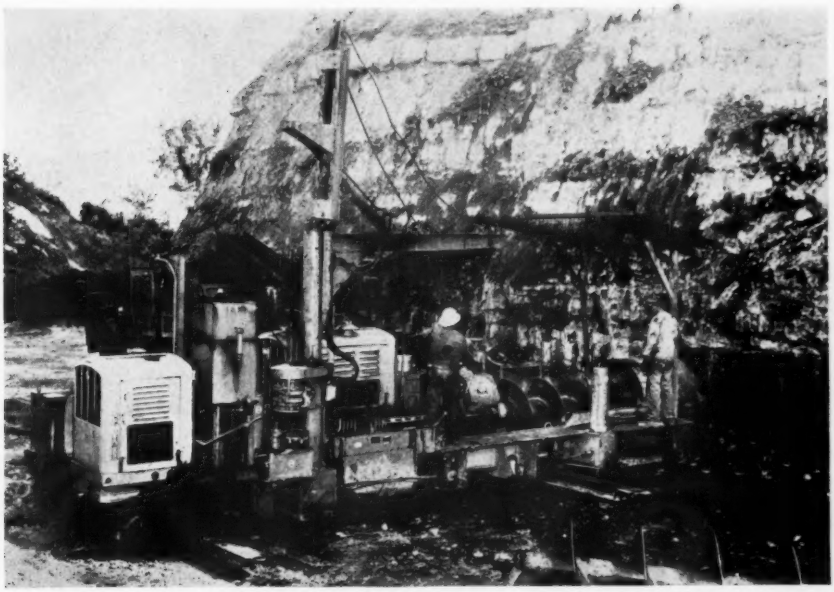
*Conveyors*

Since the design and operation of this type of equipment is generally familiar, not too much need be said about them here. Main improvements are in belt life due to the belt material, the support roller bearing design, and drive systems.




*Courtesy of Allison Div. GMC*

**Figure 12 — Torqmatic Torque Converter Showing Hydraulic Retarder Used in Braking.**



*Courtesy of The Salem Tool Company*

**Figure 13 — Coal Recovery Auger Drill.**

Large electric motors and gear reduction units provide motive power to the drive wheel. The intermediate sections are merely a repetition of the support rollers. These are usually arranged in a trough shape.

Sealed bearings are being used on some of the support rollers and automatic lubricators are being employed at some locations.

## Processing Equipment

Due to the great variety of equipment in use, only screens, crushers, and ball and rod mills are discussed since they are the most common to all operations. Conveyors are also used extensively but these have already been discussed.

*Screens*

Screens or "grizzlies," as the wider mesh ones are called, are used to classify material by size, both as it enters the processing plant and between the many successive steps in the processing.

Shaking and vibrating screens are rectangular screens mounted on a slope which either shake or vibrate the material from the high to the low end. Some designs use several layers of screen with the lower screens having smaller openings than the uppermost ones; others use only one screen with several zones of different hole size. The screening surfaces are made of either perforated plates, heavy steel bars, or woven wire, depending on the weight and size of the material they must handle. Screens are vibrated either mechanically, through eccentric cams operated by an electric motor, or by an unbalanced flywheel. The screens are mounted so that the vibrations are not transmitted to the structure housing them. Wash sprays are often used during the screening operation.

Rotary screens are used for lighter work and consist of horizontally mounted concentric cylinders made of mesh or perforated plate of various sizes; the inner-cylinder openings being larger than that of the outer. Large electric motors and reduction gears drive the drums.

*Crushers*

Together with screens these are the most common pieces of equipment in mine processing work. A differentiation is generally made between primary and secondary crushers, with the former handling the material as it comes from the pit and the latter reducing the output of the primaries still further.

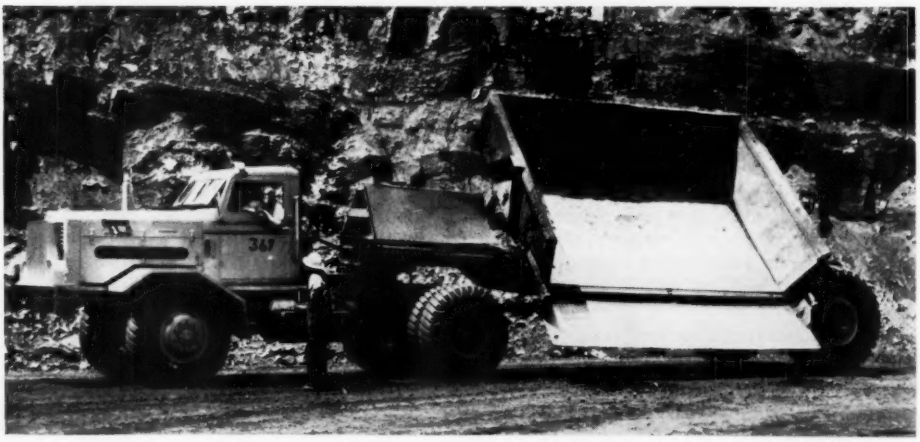
Jaw Crushers are relatively simple and rugged. Ore or stone drops between two jaws arranged in a V-shape that is open at the bottom. One jaw is fixed and the other moves toward it repeatedly, thereby crushing material between them. Motion is imparted to the movable jaw by a belt-driven eccentric shaft from which the jaw swings. With successive strokes the smaller pieces drop down slightly toward the apex of the V and are reduced further until they fall out the bottom. Changes made have been toward larger sizes, with harder

*Courtesy of Kenworth Motor Truck Co.*

**Figure 14 — 36 Ton Rear Dump Truck. 400 H.P. Diesel Engine.**

*Courtesy of Mack Trucks, Inc.*

**Figure 15 — Tandem Axle Rear Dump Truck.**



*Courtesy of Oshkosh Motors*

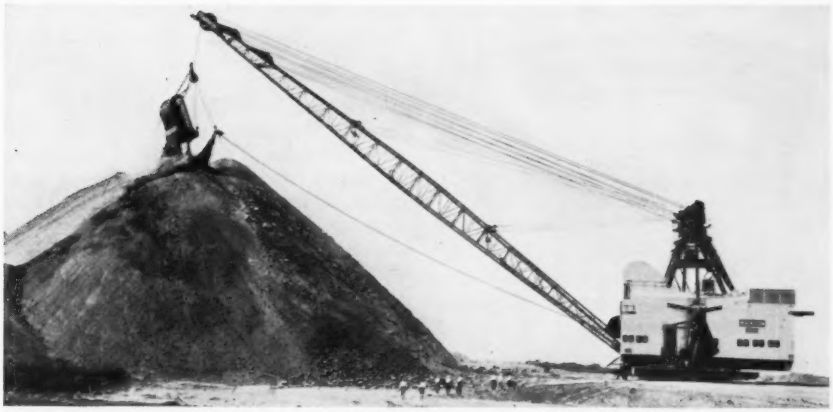
**Figure 16 — 34 Ton Side Dump Trailer With 356 H.P. LPG Engine.**

*Courtesy of Dart Truck Company*

**Figure 17 — 50 Ton Bottom Dump Tractor-Trailer With 300 H.P. Diesel Engine.**

*Courtesy of Euclid Div. GMC*

**Figure 18 — 34 Ton Rear Dump With Twin Engine 436 Total H.P. Note Exhaust Leading Up Into Dump Box.**



*Courtesy of Marion Power Shovel Co.*

**Figure 19 — Dragline With 220 Foot Boom and 35 Cubic Yard Bucket.**

removable jaw linings. Sizes with as large as 84 x 60 inch openings are in use.

Gyratory crushers are machines having a driven rotating member that is roughly conical in shape. This driven member oscillates around a vertical axis and thereby crushes material that is flowing down its sides against a surrounding fixed cone of similar shape. The motion of the cone either describes a small circle about the vertical centerline or else only the upper part moves in a circle; this motion being much like the wobble of a little boy's top as it starts to lose speed. The fixed heads have either spring or hydraulic relief systems to prevent jamming by oversize pieces or tramp iron.

The moving cone is mounted on an eccentric that is driven through bevel gearing by a belt-powered shaft and pulley. Full pressure oil lubrication of bearings, gears and other sliding surfaces is commonly provided by an internal pump.

Sizes up to seventy-two inches intake throat diameter are available. Emphasis in design has been on harder crushing ring sections of alloy or manganese steel, improved bearing arrangement to withstand shock and reduce wear, and methods of adjusting clearances to maintain a constant size product.

*Ball and Rod Mills*

These are used after the crushing stages when it is desired to reduce the material to a fine powder. Input material is generally in the order of ¾ inch in size.

The units consist of horizontally mounted rotating cylinders with either a large number of free-falling balls or longitudinal rods on the interior. The material is mixed with the balls or rods and crushed by grinding action between them.

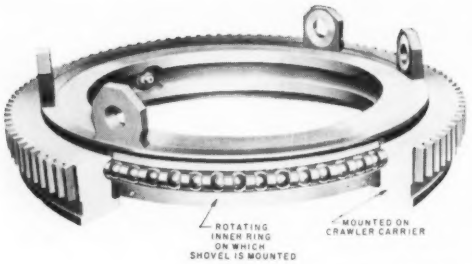
The drums are rotated through a large external ring gear on the drum by enclosed motor-driven reduction gears. Trunnion bearings are of the plain journal type with either oil pressure flotation systems or else they are grease lubricated. Improved bearing design and liner material are being used.

## LUBRICATION

It is virtually impossible to overemphasize the vital part which lubricants play in keeping an industry as highly mechanized as surface mining operating at peak efficiency. This is especially true when one considers that the environmental and operating conditions are inherently among the most adverse that can be found. Extreme dust and mud,

*Courtesy of Baldwin-Lima-Hamilton Corp.*

**Figure 20 — 6 Cubic Yard Diesel-Powered Shovel.**




*Courtesy of The Thew Shovel Company*

**Figure 21 — Novel Shovel Mounting. Usual Design Employs Center Pin and Rollers.**

wide variations in weather and temperature, heavy shock loads, and twenty-four hour operation of much of the equipment, all place severe demands on the lubricants used. Haulage equipment in particular, operates chiefly between the extremes of idling and full throttle, full load operation.

Quality lubricants have been developed by the lubricant manufacturers in cooperation with the mining and equipment industries which can fully protect moving parts under the severe conditions encountered in this service. In order to do their job, however, they must be applied to the right places in the right quantity and at the right time. To do this requires a systematic lubrication program. In addition, if optimum equipment life is to be obtained, this must be coupled with sound preventative maintenance and overhaul practices.

The cost of good lubrication is almost negligible in relation to the value of the equipment being protected. Trucks alone cost from $30,000 to $80,000 apiece and electric shovels vary from $150,000 to $2,600,000. Down time is also very costly on a round-the-clock operation of this sort. In view of these factors, it is evident that to compromise with lubricant quality is foolish economy.

Fortunately, open pit mine operators generally are giving proper emphasis to the above considerations. Trucks are serviced and checked each shift and regular oil drain and filter change periods followed. Equipment such as tractors, drilling rigs and shovels that remain outdoors are greased daily by the assistant operator or oiler. In most mines the electrical motors on all equipment are under the jurisdiction of the electrical shop who lubricate these on a separate schedule. Indoor equipment is greased and oiled daily, where required, by a crew of oilers.

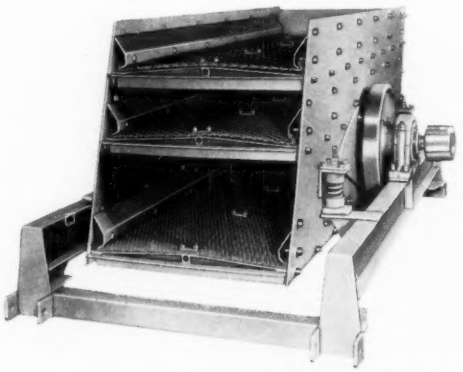
Automatic lubricators are coming into increased usage both in and out of doors in an effort to eliminate the human element and achieve controlled lubrication.

A definite trend is also evident toward a reduction in the total number of lubricants used. Consolidation where possible is very desirable, consistent of course with still maintaining adequate lubrication. It simplifies stocking and handling problems and facilitates putting into effect a planned lubrication program. To handle too many lubricants causes confusion, possible misapplication and waste. The savings effected through consolidation more than justify the use of premium grade lubricants where necessary. These afford superior protection and retain their effectiveness for a much longer period of time, thereby also adding to savings.

## Simplified Lubrication Plan for Surface Mining Excavating and Hauling Equipment

Although the basic units used vary considerably in design and function, they are made up of many similar parts from a lubrication standpoint. Considerable experience with lubrication of equipment of this type both in the mining and heavy construction fields has shown that the majority of the lubrication requirements can be handled by the basic lubricant types shown in the chart that follows. These lubricants are listed together with suggested safe lubrication intervals for each of the components they are designed to lubricate.

The plan suggested in the chart is not inflexible. Where unusual conditions dictate, alternate types of products can, and are, being employed. For example, high temperature greases are used in electrical equipment bearings or in support bearings for shovel and dragline cable drum brakes, if high ambient temperatures develop. Also, extremely low temperatures such as those occurring in Minnesota's Iron Range occasionally demand use of lower viscosity oils and softer consistency greases than those listed. Torque converters and hydraulic couplings are not shown in the chart due to the wide variation in lubrication requirements for the many



*Courtesy of Diamond Iron Works Div. of Goodman Manufacturing Company*

**Figure 22 — 3 Deck Vibrating Screen.**

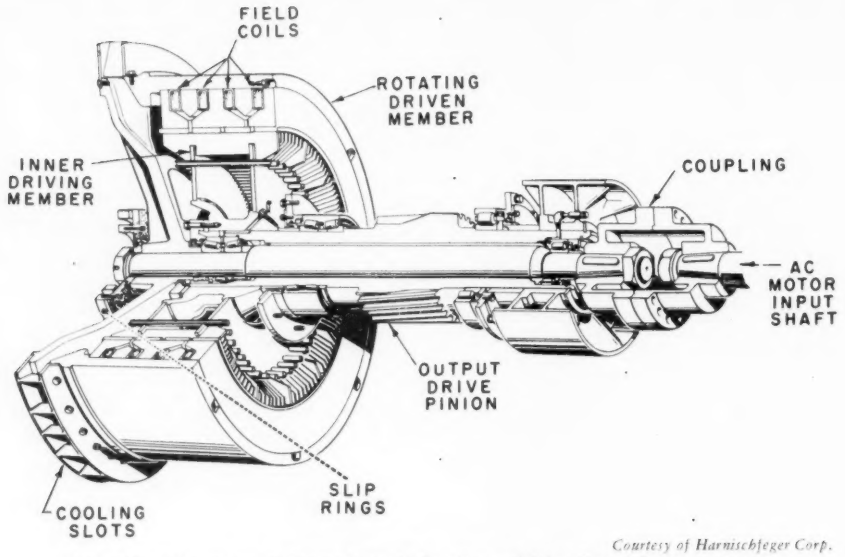
## SIMPLIFIED LUBRICATION PLAN FOR SURFACE MINING EXCAVATING AND HAULING EQUIPMENT

| *Part Requiring Lubrication* | *Lubrication Interval, Hours* | *Lubricant Type Used** 90-32°F. | 32-10°F. |
|---|---|---|---|
| Engines—Gasoline, LPG and Diesel** | 100 | Heavy Duty Engine Oil | |
| Engine Accessories—Oil Lubricated | 100 | | |
| Oil can points—Moderate loads | As required | SAE 30 | SAE 20-20W |
| Railroad Diesel Engines | 6000 | Railway Diesel Oil | SAE 40 |
| Railway Journal Bearings—Waste Packed | Keep at proper level | Premium Grade Car Oil | |
| Gear Boxes—Transmissions, Differentials | 1000 | | |
| Chain Drives | 100 | Extreme Pressure Gear Lubricant | |
| Flexible Couplings | 1000 | | |
| Universal Joints | 1000 | SAE-140 | SAE-90 |
| Other Oil Lubricated Parts—Severe Loads | 10 | | |
| Hydraulic Mechanisms (Except fluid transmissions) | 1000 | | |
| Air Compressors — | | Premium Grade Hydraulic Oil | |
| Reciprocating and Rotary | 200 | SAE-30 | SAE-10W |
| Electric Motors and Generators Oil Lubricated | 1000 | | |
| Percussion-Type Rock Drills, Air Line Lubricators | Hand Applied—Hourly Oilers—As required | Extreme Pressure Rock Drill Lubricant | |
| Grease Fittings — | | | |
| Linkages, Plain Bearings, etc. | 10 | | |
| Ball and Roller Bearings | 100 | Multipurpose Heavy Duty Grease No. 2 | |
| Hand-Packed Bearings*** | 100 | | |
| Wheel Bearings | 1000 | | |
| Track Rollers | 10 | Track Roll Lubricant | |
| Exposed Gears | As required | | |
| Railroad Traction Motor Gears | As required | Adhesive Type Gear Lubricant | |
| Wire Ropes and Cables | As required | | |

*Where standard SAE or NLGI viscosity and consistency specifications apply, they are shown for each temperature range. In other cases lubricant supplier should be consulted for proper grade.

**Except Railroad Diesel Engines.

***Except Railroad Journal Roller Bearings.



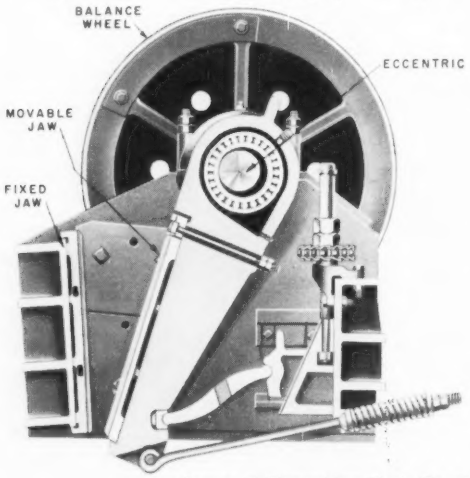

*Courtesy of Harnischfeger Corp.*

**Figure 23 — "Magnetorque" Electro-Magnetic Coupling and Drive Control For Power Shovels.**

types in use which make it impossible to give a blanket recommendation. Many other specialty products such as transformer oils, railroad journal roller bearing and traction motor greases, gel-type filter oils, water pump grease, and thread lubricant are used in surface mining. The ones given in this chart, however, cover the majority of uses, particularly in that area where the greatest overlapping of equipment manufacturer's recommendations occurs.

*Engine Oils (Heavy Duty)*

Engine oils of the heavy duty type protect against wear, rust, corrosion, and have detergent-dispersant characteristics to hold combustion products in suspension. In addition, they are non-corrosive to bearing materials and resist foam and oxidation. The requirements of the majority of engines in use are satisfied by an oil of this type meeting Military Specification MIL-O-2104A. Where an engine manufacturer specifies that their equipment requires an oil of higher detergency level such as a "Supplement 1", "Series 2" or "Series 3" oil, the oil supplier should be consulted so as to provide a product meeting these requirements.




*Courtesy of Diamond Iron Works Div. of Goodman Manufacturing Company*

**Figure 24 — Jaw Crusher.**

*Railway Diesel Oils*

Railway diesel engines pose a different problem in the balancing of additives to give the desired properties listed above, and crankcase oils specially developed for this equipment are recommended. Compatability with and lubrication of both copper-lead and silver bearings is a major consideration. In addition, the engine builders have certain requirements which must be met before they will approve the use of a given oil in their equipment.

*Gear Oils (EP Type)*

Although straight mineral oils can handle the loads developed in some gear cases, hypoid and worm gears demand an oil that has oiliness and extreme pressure additives. Since EP oils also protect against the harmful effects of shock loading and misalignment and resist foaming and oxidation, it is wise to use them in all gear boxes. These oils should be non-corrosive to system components.

Oils containing lead-naphthenate are included in this category.

*Gear Oils (Adhesive Type)*

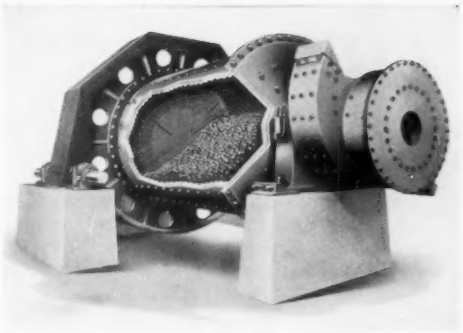
These very adhesive products contain special additives providing resistance to water action. They resist being thrown off by centrifugal force and form a tough cushion between mating parts. Cut-back versions are available for ease of application where a solvent which is incorporated evaporates after they are brushed or sprayed on. Their ability to penetrate and displace water also makes them ideal as wire rope lubricants where they seal each strand in a tough viscous film preventing rusting and fraying.

*Hydraulic Oils (Premium Grade)*

In addition to acting as a physical medium for transmitting power, hydraulic oils lubricate pumps, cylinders, and other system components. Premium oils are fortified to prevent wear and rust and to resist oxidation, sludging, and foaming.

*Rock Drill Lubricants (EP Type)*

These specially compounded lubricants atomize readily for uniform distribution in air lines. Their adhesive and EP characteristics enable them to plate-out on wear surfaces, protecting against severe loads. Their rust preventive action is very important in view of the high moisture normally found in air systems.

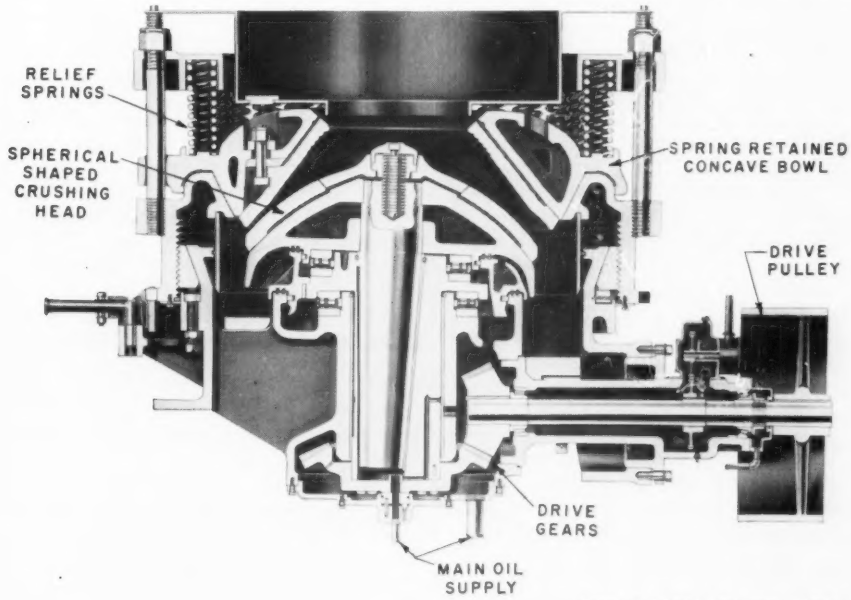


*Courtesy of Allis-Chalmers Manufacturing Company*

Figure 26 – Ball Mill.

*Multi-Purpose Heavy Duty Greases*

These are generally lithium base products with high dropping points. They should have an oil sufficiently heavy to withstand heavy wheel bearing loads. The grease must resist water contamination, resist shear breakdown, and have good low temperature pumpability. The term multi-purpose covers a great deal of territory. The integrity and reputation of the lubricant supplier are the best assurance the user has that a given grease meets all these stringent requirements. If there is any doubt that a given product can handle all the grease lubrication jobs shown in the table, it is best to use a




*Courtesy of Smith Engineering Works*

Figure 25 – Rotary Crusher.

separate grease for wheel bearing lubrication since this is the most critical requirement.

*Track Roll Lubricants*

Two types of product are available. One is a soft grease designed for use in track rollers using roller bearings and metal-to-metal seals. It needs to have good oxidation and mechanical stability. The other is a semi-fluid stringy compound which is used in lubricating the plain bearing type. It must flow out of the seals slightly thereby sealing against entry of dirt and water.

*Premium Grade Railway Car Oils*

Requirements for the minimum quality of car oils for waste-packed journal bearings are set forth in AAR Specification M 906-55. High viscosity index and low pour point are primary requisites.

In addition to the above characteristics, premium grade car oils have oiliness and extreme pressure additives and improved oxidation stability. These factors are particularly advantageous in mining use, where speeds are low and conditions in the journals are in the boundary lubrication zone much of the time. The higher loads carried by ore cars also require the added protection afforded by a fortified oil.

## Lubricants for Processing Equipment

Indoor processing equipment has either grease or oil lubricated bearings, chain or gear drives, and cables as the chief components requiring lubrication. The necessary lubricant types required for each of these components have already been described in the previous section on excavating and hauling equipment, and the same general lubricant requirements hold. Lubrication intervals shown in the table no longer apply, however, and longer relubrication intervals are usually used. Also, additional viscosity grades of both the hydraulic oils and the EP gear lubricants are necessary; the particular grade employed depending on the equipment involved.

The multipurpose grease described before will again handle most of the grease lubrication requirements of the processing equipment. However, specific grades of medium dropping point greases can be used if desired, and extreme pressure greases may be employed where unusual conditions of load or temperature make it mandatory.

It is impossible to generalize on the application of these lubricants because of the great range in design and size of equipment used in the processing operations.

## Storage and Handling of Lubricants

No discussion of lubrication can be complete without emphasizing the importance of careful storage and handling of lubricants. Even the finest lubricant cannot do its job if allowed to become contaminated. Contaminated lubricants must generally be discarded, resulting in a source of waste. Improper application also results in needless waste. It is estimated that coal strip mines alone will consume $6,300,000 of petroleum products in 1957. While a major portion of this represents fuel, it can be seen that even a small percentage of waste can amount to a sizeable sum.

Lubricants should be stored indoors, preferably in a separate oil house with someone responsible for issuing them. Where they must be stored outdoors, oil and grease drums should never be left with bungs out or lids off since this invites contamination. Drums should be stored on their sides and be equipped with faucets unless a dispensing pump is available. This prevents water from seeping into the drum.

When using lubricant guns or pumps, care should be taken to wipe off fittings and filler plugs before the lubricant is introduced. Where parts work in dirt, such as the pins of track treads and drag line cables, care should be taken to follow the general recommendation of machinery builders that no lubricant be applied.

In cold weather operation, lubricants should be stored in a warm place. If they must be heated the drum or dispenser should not be placed so close to the heat source as to scald the lubricant. This can be particularly serious in the case of greases, causing separation or change in consistency.

## SUMMARY

The equipment used in open pit mining and quarrying operations has grown to unprecedented size in recent years. Many of the largest self-propelled land-machines in existence are being used in surface mining. The enormous quantity of materials which is moved each year no longer makes "moving mountains" a measure of the impossible.

Expanded production of iron, coal and other minerals have kept pace with and helped spark the postwar growth of the American economy. The aggregate industry has been straining to keep up with the demands of the building industry and is now in the midst of supplying the tremendous quantities of material required by the Federal Road Building Program.

The equipment builders and mine operators are to be congratulated on their quickness to adapt new developments in power and materials to their needs. The lubricant suppliers take just pride in the part they have played in this growth by developing superior lubricants to keep the equipment functioning smoothly and economically.



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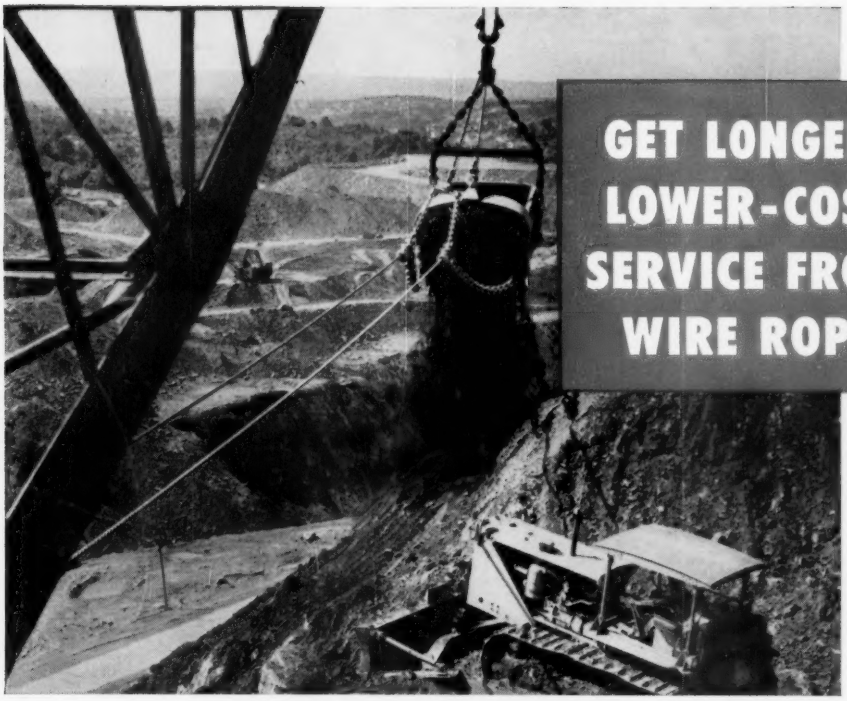

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